Amendments to the Claims

This listing of claims will replace all prior versions and listings of claims in the application:

Listing of Claims:

Claims 1 – 38 (canceled)

Claim 39 (currently amended) A method for determining forces to be applied to a user through a haptic interface, the method comprising the steps of:

generating a representation of a virtual object in graphic space;

determining a haptic interface location in graphic space in response to a location of a user-manipulated haptic interface in real space, wherein the haptic interface can penetrate a surface of the virtual object in graphic space;

determining a fiducial object location in graphic space on the surface of the virtual object, wherein the fiducial object location represents a location the haptic interface would occupy if the haptic interface could not penetrate the surface of the virtual object; and

calculating a force to be applied to the user in response to the haptic interface location and the fiducial object location.

Claim 40 (previously presented) The method of claim 39, wherein the haptic interface is represented by a single point and the fiducial object is represented by a single point.

Claim 41 (previously presented) The method of claim 39, wherein the fiducial object is represented as a three dimensional object.

Claim 42 (previously presented) The method of claim 41, wherein the three dimensional object is approximated by a series of points.

Claim 43 (previously presented) The method of claim 39, wherein the fiducial object is represented as a three dimensional object, the three dimensional object is approximated by a series of points, and the haptic interface location is a single point.

Claim 44 (previously presented) The method of claim 39, wherein the step of determining the fiducial object location comprises the steps of:

generating a representation of a virtual object within a computer; and

computing the fiducial object location, such that the distance between the fiducial object location and the haptic interface location is minimized while maintaining that the fiducial object not pass through the virtual object.

Claim 45 (previously presented) The method of claim 44, wherein the geometric representation of the virtual object is generated from a standard computer graphic file format.

Claim 46 (previously presented) The method of claim 44, further comprising the step of calculating a reaction force to send to the user, wherein the reaction force depends on a distance between the haptic interface location and the fiducial object location.

Claim 47 (previously presented) The method of claim 46, wherein the reaction force is proportional to the distance.

Claim 48 (previously presented) The method of claim 46, wherein the step of calculating the reaction force involves calculating a component of the reaction force which depends on a difference in velocity between the haptic interface location and the fiducial object location.

Claim 49 (previously presented) The method of claim 48, wherein the component of the reaction force which depends on the difference in velocity between the haptic interface location and the fiducial object location is proportional to the difference in velocity.

Claim 50 (currently amended) The method of claim 44, further comprising the step of displaying a representation of the fiducial object on a display in a location relative to the virtual object location.

Claim 51 (previously presented) The method of claim 50, wherein the fiducial object location is different from the haptic interface location.

Claim 52 (previously presented) The method of claim 50, wherein the fiducial object is substantially co-located with the haptic interface location.

Claim 53 (previously presented) The method of claim 44, wherein the method is performed iteratively until a valid fiducial object location is found.

Claim 54 (previously presented) The method of claim 53, wherein multiple surfaces of at least one virtual object are considered in calculating a valid fiducial object location.

Claim 55 (previously presented) The method of claim 44, wherein the virtual object deforms in response to force applied to the virtual object by the user.

Claim 56 (previously presented) The method of claim 55, wherein the applied force comprises at least one of a damping force, a stiffness force, and a friction force.

Claim 57 (previously presented) The method of claim 55, wherein the applied force comprises at least two of a damping force, a stiffness force, and a friction force.

Claim 58 (previously presented) The method of claim 55, wherein the applied force comprises a damping force, a stiffness force, and a friction force.

Claim 59 (canceled)

Claim 60 (currently amended) A system for determining force to be applied to a user through a haptic interface, the system comprising:

a modeling module that generates a representation of a virtual object in graphic space;

a computation module that determines a haptic interface location in graphic space in response to a location of a user-manipulated haptic interface in real space, wherein the haptic interface can penetrate a surface of the virtual object in graphic space;

a locating module that determines a fiducial object location in graphic space on the surface of the virtual object, wherein the fiducial object location represents a location the haptic interface would occupy if the haptic interface could not penetrate the surface of the virtual object; and

a force computation module that calculates a force to be applied to the user in response to the haptic interface location and the fiducial object location.

Claim 61 (previously presented) The system of claim 60, further comprising:

a simulation module that computes the fiducial object location such that distance between the fiducial object location and the haptic interface location is minimized while maintaining a condition that the fiducial object not pass through the virtual object.

Claim 62 (previously presented) The system of claim 61, further comprising a display module that displays a representation of the fiducial object on a display in a location relative to the virtual object location.

Claim 63 (previously presented) The system of claim 60, wherein the haptic interface is represented by a single point and the fiducial object is represented by a single point.

Claim 64 (previously presented) The system of claim 60, wherein the fiducial object is represented as a three dimensional object.

Claim 65 (previously presented) The system of claim 64, wherein the three dimensional object is approximated by a series of points.

Claim 66 (previously presented) The system of claim 60, wherein the fiducial object is represented as a three dimensional object, the three dimensional object is approximated by a series of points, and the haptic interface location is a single point.

Claim 67 (previously presented) The system of claim 60, further comprising:

a generation module that generates a representation of a virtual object within a computer; and

a displacement module that computes the fiducial object location such that distance between the fiducial object location and the haptic interface location is minimized while maintaining a condition that the fiducial object not pass through the virtual object.

Claim 68 (previously presented) The system of claim 60, wherein a geometric representation of the virtual object is generated from a standard computer graphic file format.

Claim 69 (previously presented) The system of claim 60, further comprising a module that calculates a reaction force to apply to the user wherein the reaction force depends on distance between the haptic interface location and the fiducial object location.

Claim 70 (previously presented) The system of claim 69, wherein the reaction force is proportional to the distance.

Claim 71 (previously presented) The system of claim 69, wherein the module that calculates the reaction force calculates a component of the reaction force which depends on a difference in velocity between the haptic interface location and the fiducial object location.

Claim 72 (previously presented) The system of claim 71, wherein the component of the reaction force which depends on the difference in velocity between the haptic interface location and the fiducial object location is proportional to the difference in velocity.

Claim 73 (currently amended) The system of claim 60, further comprising a display for displaying a representation of the fiducial object on the display in a location relative to the virtual object location.

Claim 74 (previously presented) The system of claim 73, wherein the fiducial object location is different from the haptic interface location.

Claim 75 (previously presented) The system of claim 73, wherein the fiducial object is substantially co-located with the haptic interface location.

Claim 76 (previously presented) The system of claim 60, further comprising a controller module that causes the locating module to iterate until a valid fiducial object location is found.

Claim 77 (previously presented) The system of claim 76, wherein the locating module considers multiple surfaces of one or more virtual objects in calculating a valid fiducial object location.

Claim 78 (previously presented) The system of claim 60, wherein the virtual object is adapted to deform in response to force applied to the virtual object by the user.

Claim 79 (previously presented) The system of claim 78, wherein the applied force comprises at least one of a damping force, a stiffness force, and a friction force.

Claim 80 (previously presented) The system of claim 78, wherein the applied force comprises at least two of a damping force, a stiffness force, and a friction force.

Claim 81 (previously presented) The system of claim 78, wherein the applied force comprises a damping force, a stiffness force, and a friction force.

Claim 82 (previously presented) A method for determining forces to be applied to a user through a haptic interface, the method comprising the steps of:

(a) generating a representation of an object in graphic space by defining the object as a mesh of planar surfaces, each of the planar surfaces comprising nodes;

(b) sensing a location of a user in real space;

(c) determining a haptic interface location in graphic space in response to the location of the user in real space;

(d) determining a fiducial object location on the surface of the object in graphic space;

(e) calculating a stiffness force to be applied to the user in real space in response to the haptic interface location and the fiducial object location in graphic space; and

(f) calculating a magnitude of a damping force to be applied to the user in real space in response to the haptic interface location and the fiducial object location in graphic space, further comprising the steps of:

(i) associating a damping coefficient with each of the nodes of each of the planar surfaces;

(ii) determining on which of the planar surfaces the fiducial object is located; and

(iii) computing a damping coefficient of the fiducial object location by interpolating the damping coefficients associated with the nodes of each of the planar surfaces on which the fiducial object is located.

Claim 83 (previously presented) A method for determining forces to be applied to a user through a haptic interface, the method comprising the steps of:

(a) generating a representation of an object in graphic space by defining the object as a mesh of planar surfaces, each of the planar surfaces comprising nodes;

(b) sensing a location of a user in real space;

(c) determining a haptic interface location in graphic space in response to the location of the user in real space;

(d) determining a fiducial object location on the surface of the object in graphic space;

(e) calculating a stiffness force to be applied to the user in real space in response to the haptic interface location and the fiducial object location in graphic space; and

(f) calculating a direction of a damping force to be applied to the user in real space in response to the haptic interface location and the fiducial object location in graphic space, further comprising the steps of:

(i) associating a surface normal with each of the nodes of each of the planar surfaces;

(ii) determining on which of the planar surfaces the fiducial object is located; and

(iii) computing a surface normal for the fiducial object location by interpolating the surface normals associated with the nodes of each of the planar surfaces on which the fiducial object is located.